MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 3, 2022/2023 (TERM ID 2230)

TIT3131 – INFORMATION THEORY

(All sections / Groups)

6 October 2023
9.00 am – 11.00 am
(2 Hours)

INSTRUCTIONS TO STUDENTS

1. This question paper consists of 6 pages with **Four** questions only.
2. Attempt **All** questions. All questions carry equal marks and the distribution of the marks for each question is given.
3. Please print all your answers in the Answer Booklet provided.

QUESTION 1

Question 1 contains **10 MCQ** questions, please choose the best answer and write it clearly in the answer booklet.

(a) In Lempel-Ziv coding, the subsequence in the codebook is further encoded into fixed-length blocks. [1 mark]

[A] TRUE.
[B] FALSE.

(b) The amount of information, $I(S_k)$ is directly proportional of the probability of occurrence. [1 mark]

[A] TRUE.
[B] FALSE.

(c) $\mathbf{H(S^6)}$, the entropy of the extended source, is equal to $6*\mathbf{H(S)}$, the entropy of the original source. [1 mark]

[A] TRUE.
[B] FALSE.

(d) Given a DMS, S = {A, B, C, D} and the probability of occurrence for these symbols are showed in the **Table 1**. Calculate the information gained for symbol D. [1 mark]

Table 1

S_k	A	B	C	D
p_k	0.1	*0.2*	*0.3*	*0.4*
$I(S_k)$				

[A] $I(S_B) = 3.3219$ bit/symbol
[B] $I(S_B) = 2.3219$ bit/symbol
[C] $I(S_B) = 1.3219$ bit/symbol
[D] None of the above.

(e) The basic property of linear block coder is called closure, and according to this property the sum of any two code words is another code word. [1 mark]

[A] TRUE.
[B] FALSE.

(f) Block codes in which message bits are transmitted in unaltered form are called non-systematic codes. [1 mark]

[A] TRUE.
[B] FALSE.

Continued...

(g) The mutual information of a channel is always non-negative; that is $I(X,Y)$ greater or equal to zero. [1 mark]

[A] TRUE.
[B] FALSE.

(h) From the **Table 2** below, given that the Code I is **NOT** a prefix code, estimate a suitable code for x.

[1 mark]

Table 2

Symbol	Code 1
A	00
B	01
C	x
D	1000

[A] $x = 001$.
[B] $x = 101$.
[C] $x = 1110$.
[D] None of the above.

(i) Given that message m = (11110). The message polynomial $M(D)$ is equal to $1 + D + D^2 + D^5$ [1 mark]

[A] TRUE
[B] FALSE

(j) Consider a generator matrix (6, 3) linear block code below. The generator matrix is expressed in non-systematic form. [1 mark]

$$G = \begin{bmatrix} 0 & 1 & 1 & 1 & 0 & 0 \\ 1 & 1 & 1 & 0 & 1 & 0 \\ 1 & 1 & 0 & 1 & 0 & 1 \end{bmatrix}$$

[A] TRUE
[B] FALSE

Continued...

QUESTION 2

(a) Consider the following source with discrete memoryless source with source alphabet $S = \{S_0, S_1, S_2\}$ with $p_0 = 0.55$, $p_1 = 0.25$, $p_2 = 0.2$. Prove that $H(S^2) = 2\ H(S)$. [3 marks]

(b) Construct the encoder circuit for the generator polynomial for a (6, 3) cyclic code generated by $g(D) = 1 + D + D^3$. [4 marks]

(c) Given convolutional code of path 1, path 2 and path 3 in **Figure 1**. Find g1, g2 and g3.

[3 marks]

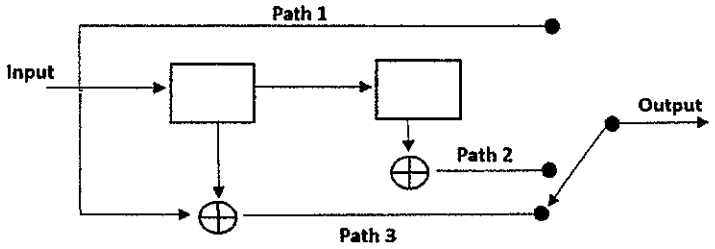

Figure 1

Continued...

QUESTION 3

(a) From the **Figure 2** below, given that $P(X) = \{0.55, 0.45\}$. Show that $\mathbf{I}(Y,X)$ is equal to $\mathbf{I}(X,Y)$. You must show all the necessary steps.

[6 marks]

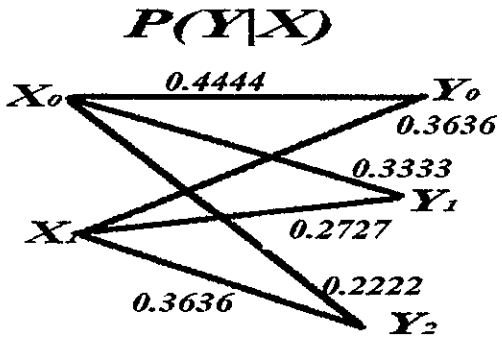

Figure 2

(b) From the **Table 3** below, use Kraft inequality to determine whether the following code are unique decodable. You must show all the necessary steps.

[4 marks]

Table 3

Symbol	Code I	Code II
A	0000	000
B	0001	111
C	0010	0000
D	1111	0001

Continued...

QUESTION 4

(a) A discrete memoryless source produces one of the five outputs $\{A, B, C, D, E\}$ randomly. The corresponding output probabilities are 0.4, 0.2, 0.2, 0.1 and 0.1.

i) Create a **Huffman** tree and **encoding table** for the source. You must show all the necessary steps. [4 marks]

ii) Calculate the **efficiency** of this code. [3 marks]

(b) Consider the generator polynomial for a (6,3) cyclic code generated by $g(D) = 1 + D + D^3$. Construct all the valid code words for the following messages in "**non-systematic**" form. Show your steps.

[3 marks]

Message	m(D)	c(D)	Code word
100			
101			
111			

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